

PORT STANLEY TIDAL LAGOON

WATER QUALITY MONITORING REPORT

*(FOR MONITORING PERIOD: JULY 2002 – MARCH
2004)*

*PREPARED BY:
SAN JUAN CONSERVATION DISTRICT
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BACKGROUND:

IN JULY OF 2002, THE SJ CONSERVATION DISTRICT BEGAN A WATER QUALITY MONITORING STUDY AT THE PORT STANLEY TIDAL LAGOON ON LOPEZ ISLAND. THIS STUDY WAS INITIATED AS PART OF A FEASIBILITY STUDY FOR RESTORATION OF THE SALT MARSH AND TIDAL LAGOON SYSTEM AT SWIFTS BAY (PORT STANLEY). THE GOAL OF THIS STUDY WAS TO DETERMINE THE OVERALL CONDITION OF WATER QUALITY IN THE LAGOON. IN PARTICULAR, NUTRIENT CONCENTRATIONS AND FECAL COLIFORMS COUNTS WERE INVESTIGATED AS AN INDICATION OF WHETHER ON-SITE SEPTIC SYSTEMS OR AGRICULTURAL RUNOFF MIGHT BE CONTRIBUTING TO THE INCREASED ALGAL BLOOMS AND GENERAL WATER QUALITY DECLINE OBSERVED BY LANDOWNERS AT THE STUDY SITE FOR THE LAST SEVERAL YEARS.

IN JULY OF 2002, VOLUNTEERS WERE TRAINED IN MONITORING LAGOON TEMPERATURE, PH, DISSOLVED OXYGEN, AND NUTRIENT CONCENTRATIONS. FECAL COLIFORM TESTING AND UPGRADED NUTRIENT MONITORING WERE ADDED TO THE STUDY IN JUNE OF 2003. FIVE SITES WERE MONITORED – FOUR IN THE LAGOON AND ONE IN SWIFTS BAY NEAR THE OUTFLOW FROM THE LAGOON. DATA WAS COLLECTED EVERY 2 WEEKS, FOR 16 CONSECUTIVE MONTHS. THIS REPORT DISCUSSES THE MONITORING DATA, AND ALSO DISCUSSES ASSOCIATED FACTORS OF WATER CONDITION AND WATER QUALITY. STUDY RESULTS WILL BE USED FOR IDENTIFYING APPROPRIATE MANAGEMENT STRATEGIES FOR THE RESTORATION PROJECT; IN ADDITION TO THE RESTORATION CONSTRUCTION MEASURES IDENTIFIED FOR REHABILITATION OF THE TIDAL WETLAND COMMUNITY AT SWIFTS BAY (PORT STANLEY).

INTRODUCTION

THE MOST RECENT GLACIATION OF LOPEZ ISLAND BEGAN ABOUT 18,000 YEARS AGO AND CONTINUED UNTIL ABOUT 14,500 YEARS AGO, WHEN GLACIAL ICE BEGAN TO MELT. AS THE ICE SHEETS MELTED RISING SEA LEVELS CAUSED EXTENSIVE EROSION OF COASTAL BLUFFS THAT WERE LARGELY COMPOSED OF UNCONSOLIDATED, GLACIALLY DEPOSITED MATERIAL. ONE OF THE EFFECTS OF ERODED GLACIAL MATERIAL BEING TRANSPORTED AND RE-DEPOSITED IS THE CREATION OF BARRIER BEACHES. BARRIER BEACHES ARE FORMED WHERE THE RELOCATED MATERIAL CREATES A BERM PARALLEL TO THE SHORELINE. THE LAND BEHIND THE BERM REMAINS TIDALLY INFLUENCED, BUT IS NOW SEMI-ENCLOSED. THIS IS ONE WAY IN WHICH A COASTAL MARSH AND LAGOON IS FORMED. (FIGURE-1)

COASTAL LAGOONS COME IN ALL TYPES OF SHAPES AND SIZES. THE MAIN FEATURE IS THAT THE MAIN PART OF THE WATER BODY IS SEPARATED FROM SOME TIDALLY INFLUENCED AREA. IN SOME CASES THE SHORELINE BERM IN FRONT OF THE LAGOON COMPLETELY CLOSES. IN THESE CASES THE LAGOON MAY BE JUST RECEIVING UPLAND (FRESHWATER) DRAINAGE FOR A NUMBER OF YEARS. AS FRESH WATER BUILDS UP IT WILL ACTUALLY PRESS BACK THE SALT WATER WATERTABLE AND YOU'LL HAVE NEARLY FRESH

WATER WITH ONLY A FEW SALT WATER SPECIES THAT CAN HANDLE THE VERY LOW SALINITY TO BEGIN WITH. IN TIME, A STRONG STORM OR A SIGNIFICANT HIGH TIDE WILL SUDDENLY BREACH THE BERM AND TIDAL WATER WILL AGAIN CONNECT AGAIN WITH THE LAGOON.

IN THE CASE OF THE PORT STANLEY LAGOON THE BARRIER / BERM WAS ENHANCED DURING ROAD CONSTRUCTION MANY YEARS AGO, AND FULLY ENCLOSES THE SALT MARSH AND LAGOON. THE EXISTING TIDEGATE PROVIDES THE ONLY MEANS FOR TIDAL EXCHANGE AND THE SALT MARSH AND LAGOON ARE OTHERWISE CUT-OFF FROM TIDAL INFLUENCE. SUBSEQUENTLY, THERE IS A GREATER AMOUNT OF FRESH WATER THAN SALT WATER COMING INTO THE LAGOON. DUE TO LOW TIDAL FLUSHING THE SEDIMENT DEPOSITION PROCESS IS QUITE ADVANCED.

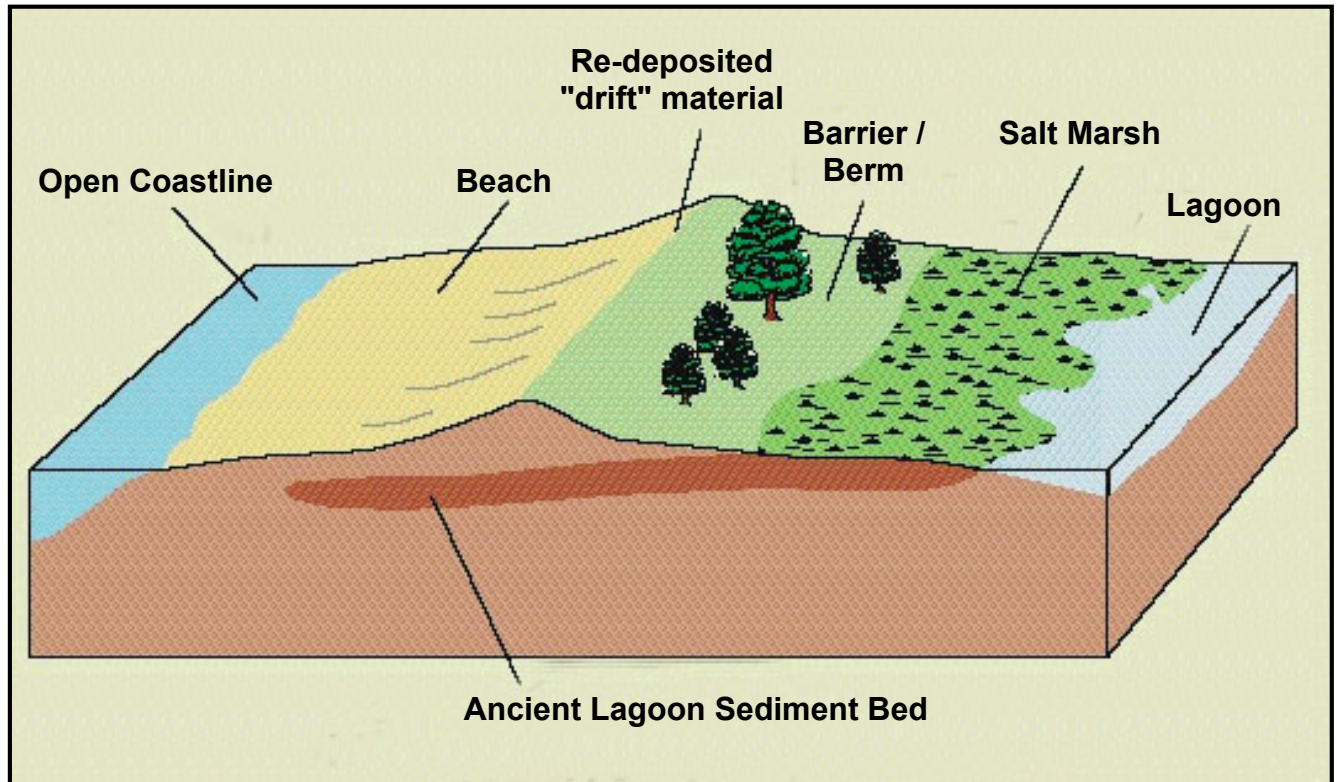


FIGURE-1: TYPICAL STRUCTURE OF BARRIER BEACH AND TIDAL MARSH / LAGOON

TROPHIC STATE

TROPHIC STATE IS AN INDICATOR OF WATER QUALITY AND OF THE AGE OF A WATERBODY. LENTIC (STANDING) WATER BODIES CAN BE DIVIDED INTO THREE CATEGORIES BASED ON TROPHIC STATE – *OLIGOTROPHIC*, *MESOTROPHIC*, AND *EUTROPHIC*. THESE CATEGORIES REFLECT A WATERBODIES CLARITY AND ACCORDINGLY, THE LEVEL OF NUTRIENT CONCENTRATIONS IT CONTAINS. THIS EQUATES TO WHAT STAGE (IN LIFE-CYCLE) THE WATERBODY IS CURRENTLY AT.

OLIGOTROPHIC: THIS IS THE EARLY STAGE IN THE LIFE OF A LENTIC WATERBODY. OLIGOTROPHIC CONDITIONS ARE GENERALLY CLEAR, DEEP AND FREE OF WEEDS OR

LARGE ALGAE BLOOMS. THEY ARE LOW IN NUTRIENTS AND DO NOT SUPPORT LARGE FISH POPULATIONS.

MESOTROPHIC: MESOTROPHIC CONDITIONS ARE THE NEXT STAGE IN LAKE, POND OR LAGOON'S AGING PROCESS. THERE IS INCREASED BIODIVERSITY (MORE VARIETY OF PLANT AND ANIMAL SPECIES...A RICHER COMMUNITY, BIOLOGICALLY). AQUATIC PLANT PRODUCTION INCREASES DUE TO THE ACCUMULATION OF BOTTOM SEDIMENTS, WHICH IN TURN CAUSE PHOSPHORUS CYCLING. WITH INCREASED PHOSPHORUS AVAILABLE, AQUATIC PLANT PRODUCTION INCREASES.

EUTROPHIC: EUTROPHIC CONDITIONS CAN BE OBSERVED IN THE LATER STAGES OF THE WATERBODIES AGING PROCESS (MOVING TOWARDS DRYING BACK INTO THE LAND). EUTROPHIC WATERBODIES ARE HIGH IN NUTRIENTS AND SUPPORT A LARGE BIOMASS (MANY PLANTS AND ANIMALS LIVING IN THE LAKE). EUTROPHIC ENVIRONMENTS ARE USUALLY EITHER WEEDY OR SUBJECT TO FREQUENT ALGAE BLOOMS, OR BOTH.

CULTURAL EUTROPHICATION

THE TROPHIC AGING PROCESS DESCRIBED ABOVE OCCURS IN ALL LENTIC WATERBODIES, CAUSING THEM TO CHANGE FROM *OLIGOTROPHIC* TO *EUTROPHIC* OVER TIME, AND EVENTUALLY TO FILL IN COMPLETELY. THE NATURAL TIMEFRAME FOR A WATERBODY TO REACH A STATE OF EUTROPHICATION TAKES OVER HUNDREDS, EVEN THOUSANDS OF YEARS, HOWEVER, HUMAN ACTIVITIES CAN GREATLY ACCELERATE THE PROCESS OF EUTROPHICATION.....THIS IS CALLED "CULTURAL EUTROPHICATION". CULTURAL EUTROPHICATION CAN TAKE PLACE IN AS FEW AS TEN YEARS. RUNOFF, ESPECIALLY FROM DEVELOPED OR AGRICULTURAL AREAS, MAY CARRY NUTRIENT-RICH FERTILIZERS, SEDIMENT, OR SEPTAGE AND WASTEWATER EFFLUENT. THESE BY-PRODUCTS OF HUMAN ACTIVITY WHEN REACHING A WATERBODY ADD TO NATURAL ACCUMULATIONS OF NUTRIENTS AND, CONSEQUENTLY ACCELERATE EUTROPHICATION. MOST HUMAN-ORIENTED LAND USES, INCLUDING LOGGING AND ASSOCIATED FORESTRY PRACTICES, AGRICULTURE, AND RESIDENTIAL DEVELOPMENT CONTRIBUTE TO *CULTURAL EUTROPHICATION*.

THE PORT STANLEY TIDAL LAGOON IS IN A EUTROPHIC STAGE OF SUCCESSION. IN FACT, PHOSPHATE LEVELS ARE SO EXTREMELY HIGH THAT THE LAGOON WOULD ACTUALLY BE MORE ACCURATELY CATEGORIZED AS A HYPEREUTROPHIC WATERBODY (SEE "PHOSPHORUS" DISCUSSION LATER IN THIS PAPER). IT IS LIKELY THAT THIS HYPEREUTROPHIC CONDITION IS BEING (HAS BEEN) AIDED BY ANTHROPOGENIC (HUMAN-INDUCED) INPUTS.

THE GOAL OF THE PORT STANLEY MONITORING HAS BEEN TO INVESTIGATE THE CURRENT CONDITION OF WATER QUALITY IN THE LAGOON AND TO DETERMINE WHETHER WATER QUALITY IMPROVEMENT MEASURES, IN ADDITION TO PROPOSED RESTORATION ACTIVITIES, SHOULD BE ARRANGED. MANY WATER QUALITY MONITORING PROGRAMS ARE GEARED TOWARD MONITORING "CULTURAL EUTROPHICATION" IN ORDER TO PROVIDE MANAGEMENT DIRECTION. DUE TO CURRENT NUTRIENT CONCENTRATIONS IN THE PORT STANLEY LAGOON, POST RESTORATION CONSTRUCTION

PORT STANLEY TIDAL LAGOON: PHYSICAL CHARACTERISTICS

LAGOON MONITORING

BEHAVIOR / INFLUENCE OF NUTRIENTS IN THE LAGOON

NUTRIENTS ARE IONS THAT ORGANISMS REQUIRE FOR GROWTH AND SURVIVAL. IN NATURAL CONDITIONS MOST OF THE NUTRIENTS REQUIRED FOR PLANT AND ANIMAL GROWTH ARE SUPPLIED FROM SOILS AND ROCKS IN THE DRAINAGE BASIN FEEDING THE WATERBODY. MOST ARE SUPPLIED IN MUCH HIGHER CONCENTRATIONS THAN REQUIRED BY ORGANISMS. REGARDING AQUATIC VEGETATION GROWTH (PRIMARY PRODUCTION) PHOSPHORUS IS THE ELEMENT MOST LIKELY TO BE GROWTH-LIMITING FOR ALGAE, HOWEVER, IN MARINE ENVIRONMENTS, OR THOSE INFLUENCED BY SALINITY, NITROGEN MAY BECOME THE FACTOR LIMITING PLANT GROWTH IN A LAKE OR OTHER FRESH WATERBODY. THEREFORE, IN SURFACE WATER MONITORING FOR TIDALLY INFLUENCED SYSTEMS NITROGEN AND PHOSPHORUS ARE IMPORTANT NUTRIENTS TO MONITOR.

NITROGEN

NITROGEN (N) CAN OCCUR IN MANY FORMS IN NATURAL SURFACE WATERS, E.G., AMMONIA, NITRATE, NITRITE. NITROGEN CAN ALSO CYCLE BETWEEN THESE DIFFERENT FORMS. INORGANIC FORMS OF NITROGEN (NITRATE, NITRITE, AMMONIA) ARE USED BY AQUATIC PLANTS AND ALGAE. THEREFORE, THESE ARE THE NITROGEN FORMS THAT ARE MOST COMMONLY TESTED AS, THEY ARE MOST BIOLOGICALLY AVAILABLE. IN PARTICULAR, *NITRATE* IS IMPORTANT BECAUSE IT IS RELATIVELY SOLUBLE IN WATER COMPARED TO OTHER NITROGEN FORMS. THE FORMATION OF NITRATE OCCURS WHEN DECOMPOSING ORGANIC MATTER RELEASES AMMONIA, WHICH IS CONVERTED TO NITRATE IF OXYGEN IS PRESENT.

IN SHALLOW WATERBODIES (LESS THAN 3 METERS) THE LOADING OF NUTRIENTS IS PROPORTIONALLY HIGHER THAN IN DEEPER WATERBODIES. ALSO, THE LOSSES OF NUTRIENTS TO POTENTIAL DEPOSITORIES, SUCH AS THE SEDIMENTS OR OUTFLOW ARE LOWER, AND THE RATES OF NUTRIENT RECYCLING ARE FASTER IN SHALLOW WATERBODIES, (I.E., LAGOONS, PONDS).

NUTRIENTS ENTER THE SYSTEM VIA RUN-OFF OR BY TIDAL EXCHANGE. ONCE NUTRIENTS ARE IN THE SYSTEM THEY CAN BE TAKEN UP DIRECTLY BY PLANTS OR ANIMALS, OR ATTACH TO PARTICLES AND SETTLE ON THE LAGOON FLOOR. NUTRIENTS IN SEDIMENTS ON THE LAGOON FLOOR USUALLY OCCUR IN A FORM THAT IS NOT DIRECTLY AVAILABLE TO PLANTS BUT THEY ARE PROCESSED BY CHEMICAL AND BIOLOGICAL REACTIONS FOR RELEASE BACK TO THE WATER IN A FORM THAT PLANTS CAN TAKE UP. (IT IS IMPORTANT TO STRESS THAT THE SEDIMENTS HAVE NOT CREATED 'NEW' NUTRIENTS; THEY ARE THE PLACE WHERE NUTRIENTS BROUGHT IN FROM THE CATCHMENT ARE RECYCLED.)

NUTRIENTS ARE LOST BY DIRECT REMOVAL OF PLANTS OR ANIMALS FROM THE LAGOON OR BY THE PRODUCTION OF NITROGEN GAS IN SEDIMENTS (DENITRIFICATION). A WEB OF INTERACTIONS BETWEEN PLANTS AND ANIMALS ACTS TO MAINTAIN POPULATIONS OF PHYTOPLANKTON (MICROSCOPIC, FLOATING PLANTS) , ZOOPLANKTON (MICROSCOPIC, FLOATING ANIMALS) AND CARNIVORES (LARGER ANIMALS) SUCH AS SOME FISH.

DISRUPTION OCCURS WHEN, FOR EXAMPLE, EXCESSIVE INPUTS OF NUTRIENTS LEAD TO PLANT PRODUCTION IN EXCESS OF GRAZERS' ABILITIES TO CONSUME IT. DISRUPTIONS TO GRAZERS OR CARNIVORES RESULT IN A CHANGED COMMUNITY STRUCTURE OR CAN BLOCK KEY BIOCHEMICAL PROCESSES (SUCH AS DENITRIFICATION).

THE THRESHOLDS FOR NUTRIENT TESTING IN THE LAGOON WERE BASED ON REGIONAL STANDARDS SET BY THE ENVIRONMENTAL PROTECTION AGENCY FOR LAKES. THEY ARE AS FOLLOWS:

AMMONIA (NH₄) = <0.10 MG/L

NITRATE (NO₃) = <0.10 MG/L

TESTING METHODS FOR THESE FORMS OF NITROGEN IN THE PORT STANLEY LAGOON WERE CARRIED OUT USING A ORBECO "THE ANALYST" ELECTRONIC COLORIMETER. TESTING RANGES FOR THE PARAMETERS MONITORED WITH THIS EQUIPMENT ARE LISTED BELOW.

AMMONIA 0.00 - 6.80 MG/L

NITRATE 0.00 - 1.00 MG/L

NITROGEN MONITORING OF THE PORT STANLEY LAGOON:

Monitoring data for nitrate concentrations in the lagoon, over a ten-month period, beginning in July of 2003. During this period 30 out of 35 water samplings tested nitrate concentrations at a level greater than the preferred threshold of 0.10 mg/L. Overall, nitrate levels ranged from 0.02 – 0.71 mg/L.

Monitoring data for ammonia concentrations during the monitoring period showed ammonia at a level greater than the preferred threshold of 0.10 mg/L in 35 out of 35 samplings. In fact, of the 35 samplings 75% measured ammonia levels as high as 3.0 mg/L or greater. (threshold is 0.10 mg/L). Overall, ammonia concentrations measured from 0.34 – 5.43 mg/L.

PHOSPHORUS

MOST NATURAL LENTIC (STANDING WATER) WATERBODIES HAVE "TOTAL PHOSPHORUS" CONCENTRATIONS OF BETWEEN .001 AND .100 MG/L (I.E., BETWEEN 1 AND 100 µG/L) . PHOSPHORUS IN RELATION TO THE TROPHIC STATES DISCUSSED EARLIER WOULD TYPICALLY BE CATEGORIZED INTO THE FOLLOWING RANGE(S):

OLIGOTROPHIC (LOW LEVEL) = .005 - .010 MG/L

MESOTROPHIC = .010 - .030 MG/L

EUTROPHIC (HIGH LEVEL) = .030 - .100 MG/L

THESE RANGES ARE FOR MEASURING "TOTAL PHOSPHORUS", OF WHICH ROUGHLY, ONLY 20% IS INORGANIC AND READILY AVAILABLE TO ORGANISMS. THIS INORGANIC 20% -- WHAT WE REFER TO AS "REACTIVE" PHOSPHORUS, OR "PHOSPHATE" – IS WHAT WE MEASURED IN THE PORT STANLEY LAGOON (NOT THE TOTAL PHOSPHORUS LEVEL). *SO, WE WOULD EXPECT TO SEE THE LEVEL OF PHOSPHATE (REACTIVE PHOSPHORUS) IN A*

"NATURAL" STANDING WATERBODY TO BE ROUGHLY 20% OF 0.001-1.000 MG/L, WHICH IS A RANGE OF 0.00020 – 0.20 MG/L. FOLLOWING THIS, WE WOULD LOOK FOR THE ASSOCIATED LEVELS OF PHOSPHATES ("REACTIVE" PHOSPHORUS) IN OLIGOTROPHIC, MESOTROPIC, AND EUTROPHIC STATES, ROUGHLY, TO BE AS FOLLOWS:

OLIGOTROPHIC (LOW LEVEL) = .005 - .010 MG/L ÷ .020 = .001 - .002 MG/L

MESOTROPIC = .010 - .030 MG/L ÷ .020 = .002 - .002 - .006 MG/L

EUTROPHIC (HIGH LEVEL) = .030 - .100 MG/L ÷ .020 = .006 - .020 MG/L

NOTE: PHOSPHATE LEVELS ABOVE 0.020 MG/L WOULD BE CONSIDERED EXTREMELY HIGH AND CATEGORIZED AS "HYPEREUTROPHIC".

THE PHOSPHORUS CONCENTRATIONS DISCUSSED ABOVE DEAL WITH "NATURAL" SURFACE WATERBODIES. FOR OUR REGION THE ENVIRONMENTAL PROTECTION AGENCY HAS ESTABLISHED A THRESHOLD OF ≤ 0.00875 MG/L FOR PHOSPHATE IN LAKES (OR STANDING WATER SYSTEMS). THIS THRESHOLD WAS USED AS A BASELINE FOR MONITORING PHOSPHATE CONCENTRATIONS IN THE PORT STANLEY LAGOON. DUE TO HUMAN IMPACT DURING THE LAST 50-100 YEARS, WE WOULD EXPECT TO SEE HIGHER PHOSPHORUS CONCENTRATIONS AT THE PORT STANLEY LAGOON THAN THOSE LEVELS TYPICALLY FOUND IN MORE NATURAL (UNDISTURBED) CONDITIONS. THEREFORE, OUR TARGET THRESHOLD FOR PHOSPHATE CONCENTRATIONS WILL BE SET AT 0.005 MG/L.

PHOSPHORUS AND PH INTERACTION: THE PHOSPHORUS LEVEL IN THE SEDIMENT IS GENERALLY RICHER THAN IN THE SURROUNDING WATER. MANY FACTORS CAN AFFECT THE TRANSPORT OF PHOSPHORUS BETWEEN SEDIMENT AND WATER. ONE FACTOR IS THE PH, WHICH AFFECTS THE EXCHANGE OF PHOSPHORUS BETWEEN SEDIMENT AND WATER. AT PH VALUES BELOW 8, PHOSPHATE BINDING TO METALS IS STRONG, WHEREAS AT HIGHER PH VALUES, HYDROXIDE IONS (OH⁻) ARE EXCHANGED WITH THE PHOSPHATE, WHICH THEN BECOMES SOLUBLE IN THE WATER. THIS MAY BE AN IMPORTANT PART OF INPUT OF PHOSPHORUS TO THE WATER OF EUTROPHIC WATERBODIES WITH HIGH PRIMARY PRODUCTION, I.E., EXCESSIVE VEGETATION. ADD TO THIS THE FACT THAT HIGH PRIMARY PRODUCTION INCREASES THE PH OF THE WATER, AND THEREBY PROMOTES EVEN MORE PHOSPHORUS RELEASE, WHICH IN TURN PROMOTES EVEN HIGHER ALGAL PRODUCTION.

THIS DYNAMIC IS LIKELY AT PLAY IN THE PORT STANLEY LAGOON, WHICH *IS* EUTROPHIC AND *DOES* EXHIBIT HIGH PRIMARY PRODUCTION DURING THE GROWING SEASON. LAGOON MONITORING DATA SHOWS THAT 75% OF PH SAMPLINGS MEASURED GREATER THAN 8 ON THE PH SCALE. THEREFORE, DATA INDICATES THAT THE POTENTIAL FOR HIGH PRIMARY PRODUCTION DUE TO INTERACTION OF PH LEVELS IS PRESENT.

TESTING METHODS FOR REACTIVE PHOSPHORUS (ORTHOPHOSPHATE) IN THE PORT STANLEY LAGOON WERE CARRIED OUT USING AN ORBECO ELECTRONIC COLORIMETER. THE TESTING RANGE FOR MONITORING ORTHOPHOSPHATE WITH THIS EQUIPMENT IS LISTED BELOW.

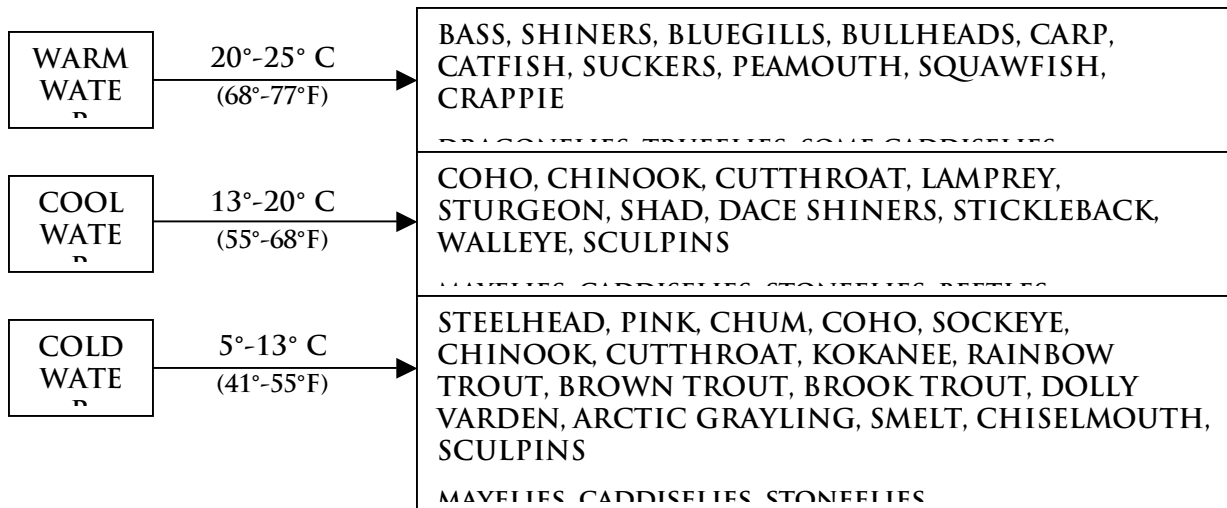
PHOSPHATE 0.00 – 4.00 MG/L

PHOSPHORUS MONITORING IN THE PORT STANLEY LAGOON:

Phosphate levels monitored in the lagoon during the 10-month monitoring period showed phosphate concentrations to be higher than the monitoring threshold (0.005 mg/L) in 100% of the samplings (high concentrations in 26 out of 26 samples). Overall, phosphate levels during this period ranged from 0.06 --0.65 mg/L. Phosphate concentrations in the lagoon do not appear to be seasonally influenced.

TEMPERATURE

TEMPERATURE HAS TRADITIONALLY BEEN RECOGNIZED AS A KEY ENVIRONMENTAL FACTOR IN SURFACE WATER ECOSYSTEMS, AFFECTING FOR EXAMPLE, DISTRIBUTION PATTERNS, BEHAVIOR, AND METABOLIC RATES OF AQUATIC ORGANISMS (INCLUDING FISH). MOST AQUATIC ORGANISMS ARE *POIKILOTHERMIC*, WHICH MEANS THAT THEIR INTERNAL TEMPERATURE VARIES IN ASSOCIATION WITH THE SURROUNDING (ENVIRONMENTAL) TEMPERATURE. EACH AQUATIC SPECIES HAS A SPECIFIC TEMPERATURE RANGE, OUTSIDE OF WHICH THEY WILL NOT SURVIVE. THERE ARE THREE OPTIMAL TEMPERATURE RANGES FOR AQUATIC LIFE, SHOWN BELOW.



THERE ARE OTHER FACTORS ASSOCIATED WITH WATER TEMPERATURE THAT CONTRIBUTE TO THE DECLINE OR DEATH OF AQUATIC ORGANISMS. THE AMOUNT OF OXYGEN THAT WATER CAN HOLD IN SOLUTION DECREASES WITH INCREASING TEMPERATURE. AS IS TRUE WITH WATER TEMPERATURE, AQUATIC ORGANISMS REQUIRE A CERTAIN AMOUNT OF DISSOLVED OXYGEN TO MAINTAIN LIFE SYSTEMS. DECLINING OXYGEN CONCENTRATIONS IN WATER IS ONE FACTOR RESULTING IN A SEVERE DETERIORATION OF LIVING CONDITIONS FOR MOST FRESHWATER ORGANISMS. IN ADDITION, TEMPERATURES INFLUENCE THE ACTIVITY OF PARASITES, DISEASE, AND THE SENSITIVITY OF AQUATIC ORGANISMS TO DISEASE. CONVERSELY, IN A SHALLOW WATERBODY WIND MIXING WILL INCREASE DISSOLVED OXYGEN LEVELS.....SUCH IS THE CASE IN THE PORT STANLEY LAGOON. ALTHOUGH WATER TEMPERATURE IS SEASONALLY QUITE HIGH, DISSOLVED OXYGEN LEVELS WERE NOTICEABLY EXCALATED THROUGHOUT THE MONITORING PERIOD, SOMETIMES MEASURING AS HIGH AS 25.0 MG/L (THRESHOLD IS >9.5 MG/L)

SHALLOW WATERBODIES TEND TO *NOT* HAVE A THERMALLY DISTINCT HYPOLIMNION (BOTTOM LAYERS) LIKE THE DEEPER SURFACE WATER FEATURES. IN GENERAL, BASIN DEPTHS <5 - 7 METERS (15 - 21FT.) DO NOT HAVE THERMAL STRATIFICATION FOR ANY APPRECIABLE LENGTH OF TIME. AS A RESULT, WATER COMMONLY CIRCULATES FOR LONG PERIODS, OR CONTINUOUSLY. DUE TO THIS, NOT ONLY ARE THE LOADINGS OF NUTRIENTS PROPORTIONALLY HIGHER IN A SHALLOW LAKE (LIKE THE PORT STANLEY LAGOON), BUT; THE RATE OF NUTRIENT RECYCLING IS FASTER, AND THE POTENTIAL FOR NUTRIENTS DEPOSITING IN SEDIMENT OR OUTFLOW IS LOWER IN A SHALLOW WATERBODY. ALSO, WIND AND WAVES CAN CIRCULATE WATER AS DEEP AS 20 – 30 FT., SO A SHALLOW WATERBODY WOULD REMAIN FAIRLY MIXED THROUGHOUT THE YEAR. THEREFORE IN SHALLOW SURFACE WATER SYSTEMS LIKE THE PORT STANLEY LAGOON, WE MIGHT EXPECT TO SEE MORE HOMOGENOUS READINGS OF TEMPERATURE, DISSOLVED OXYGEN AND PH THAN WOULD BE FOUND IN DEEPER, STRATIFIED WATERBODIES.

TEMPERATURE IN THE PORT STANLEY LAGOON:

Due to it's small size and shallow depth, the Port Stanley lagoon is seasonally very warm, ranging from 23.5° – 33.5° C (May-September). Because the lagoon is a part of the watershed drainage system that drains directly to marine waters, the state's water quality standard for water temperature is set at <16°C. Water temperatures in the Port Stanley lagoon exceeded this limit in more than 40% of samples tested. As would be expected, all the temperature readings that exceeded the threshold were taken from May thru September.

PH

THE STATE'S REQUIREMENT FOR PH RANGE IS 6.5 – 8.5. TESTING SHOWED PH LEVELS SLIGHTLY ELEVATED THROUGHOUT THE MONITORING; AND PH EXCEEDED THE STATE'S STANDARD IN 43% OF THE SAMPLINGS. THE HIGHER PH LEVELS DID APPEAR MOST OFTEN FROM JULY THRU DECEMBER.

DISSOLVED OXYGEN

OXYGEN IS, OF COURSE, A NECESSARY REQUIREMENT FOR ALL AEROBIC ORGANISMS (AIR BREATHING ANIMALS), WHICH INCLUDE THE MAJORITY OF FRESHWATER SPECIES. THE MAJOR INPUTS OF OXYGEN IN SURFACE WATERBODIES ARE EITHER BY DIFFUSION FROM THE ATMOSPHERE (SMALL PERCENTAGE) OR BY RELEASE FROM PLANTS DURING PHOTOSYNTHESIS. ALSO, THE AMOUNT OF OXYGEN FLUCTUATES WITH WATER TEMPERATURE CHANGES, WITH BIOLOGICAL PRODUCTIVITY (*RESPIRATION AND PHOTOSYNTHESIS*), AND WITH WAVE OR WIND ACTION.

OXYGEN IS PRODUCED WHENEVER GREEN PLANTS GROW THROUGH *PHOTOSYNTHESIS*, WHICH ONLY OCCURS DURING DAYLIGHT HOURS AND ONLY TO THE DEPTHS WHERE SUNLIGHT PENETRATES. THE AMOUNT OF PHOTOSYNTHESIS DEPENDS ON THE QUANTITY OF PLANTS, NUTRIENT AVAILABILITY, AND WATER TEMPERATURE. HIGHER TEMPERATURES SPEED UP THE PROCESS. IN ADDITION, AQUATIC PLANTS AND ANIMALS CONSTANTLY USE OXYGEN TO BREAK DOWN SUGAR AND OBTAIN ENERGY BY A PROCESS CALLED *RESPIRATION*. THE COMBINATION OF THESE TWO REACTIONS LARGELY DETERMINES THE AMOUNT OF OXYGEN IN A LAKE AT DIFFERENT TIMES OF THE DAY AND AT DIFFERENT DEPTHS. DURING DAYLIGHT HOURS, IT IS NOT UNCOMMON TO FIND

OXYGEN VALUES IN SURFACE WATERS THAT EXCEED TYPICAL LEVELS ("SUPERSATURATION"), WHILE AT NIGHT OR EARLY MORNING BEFORE PHOTOSYNTHESIS BEGINS THEY MAY FALL BELOW THOSE VALUES. WATERBODIES WITH HIGH BIOLOGICAL ACTIVITY UNDERGO GREATER FLUCTUATIONS THAN THOSE WITH FEW PLANTS AND ANIMALS.

DISSOLVED OXYGEN IN THE PORT STANLEY LAGOON:

Washington state's allowed minimum for dissolved oxygen in surface waters is set at ≥ 9.5 mg/L. Lagoon monitoring showed dissolved oxygen levels met this threshold in 99% of samples tested. In fact, due to wind-mixing dissolved oxygen levels in the lagoon often greatly exceeded the 9.5 mg/L required minimum.

FECAL COLIFORMS:

FECAL COLIFORMS COUNTS PROVIDE AN INDICATION OF WHETHER THERE IS A FECAL SOURCE CONTAMINATING THE SUBJECT WATERBODY. TO DATE, 12 FECAL COLIFORM TESTS HAVE BEEN CONDUCTED IN THE LAGOON. OF THESE, 4 SAMPLES SHOWED FECAL COUNTS EXCEEDING THE STATE'S REQUIRED LIMIT OF <50 COLONIES / 100 ML SAMPLE WATER. ELEVATED COUNTS SHOWED FECAL COLIFORM COLONIES OF 2000+ / 100ML, 1000+ / 100ML, AND 114 / 100ML. THE SOURCE OF CONTAMINATION IS UNDETERMINED. FECAL COLIFORMS LIVE IN THE INTESTINES OF WATER-BLOODED ANIMALS, THEREFORE, THE SOURCE COULD BE HUMAN (I.E., FAILING SEPTIC SYSTEMS), LIVESTOCK GENERATED, OR COULD BE DUE TO THE LARGE NUMBER OF BIRDS THAT USE THE LAGOON. THERE ARE 13 RESIDENCES LINING THE SHORELINE BERM, MOST OF WHICH ARE PART-TIME RESIDENTS. ALTHOUGH ON-SITE SEPTICS ARE ANTIQUATED, OVERUSE WOULD NOT APPEAR TO BE A FACTOR. ADJACENT PASTURELAND COULD BE CONTRIBUTING FECAL COLIFORMS THROUGH SURFACE RUNOFF. PRELIMINARY INVESTIGATION SUGGESTS THAT HIGH BIRD USE IN THE LAGOON IS THE MAJOR CONTRIBUTOR OF FECAL COLIFORMS. IF FECAL COUNTS REMAIN HIGH FOLLOWING RESTORATION, THESE OTHER SOURCES SHOULD BE INVESTIGATED.

FECAL COLIFORMS IN THE PORT STANLEY LAGOON:

The maximum allowed number of fecal coliforms in surface waters of San Juan County is <50 colonies / 100mL of sample water. Lagoon monitoring showed coliform counts as high as 2000 / 100mL. The suspected source is local bird populations, however, if high counts continue following restoration other contamination sources should be investigated.

CONCLUSION:

THE PORT STANLEY TIDAL LAGOON WATER QUALITY MONITORING STUDY PROVIDES INFORMATION ABOUT SEVERAL IMPORTANT COMPONENTS OF WATER QUALITY; THE RESULTING DATA OF WHICH CAN BE USED AS AN INDICATION OF THE OVERALL CONDITION OF WATER QUALITY IN THE LAGOON.

TEMPERATURE WAS VERY HIGH IN SUMMER MONTHS, RANGING FROM 23.5° -- 33.5°C. THESE TEMPERATURES ARE TOO HIGH FOR MANY AQUATIC ORGANISMS. THE LETHAL TEMPERATURE FOR SALMONIDS AND SOME IMPORTANT AQUATIC INSECTS IS TEMPERATURES ABOVE 25° C. THEREFORE, THESE WARMER SUMMER TEMPERATURES WOULD NOT SUPPORT IMPORTANT FORAGE FISH OR PACIFIC SALMON SPECIES, SUCH AS COHO AND CHINOOK (OPTIMAL WATER TEMPERATURE RANGE IS 13° - 20° CELCIUS). ALTHOUGH SMALL THREE-SPINED STICKLEBACK (*GASTEROSTEUS ACULEATUS*) AND SCULPINS (*COTTIDAE*) HAVE BEEN OBSERVED IN THE LAGOON AND DRAINAGE DITCH, IT IS UNLIKELY THAT THEIR POPULATIONS SURVIVE THE SUMMER HEATING OF THE LAGOON.

DISSOLVED OXYGEN LEVELS IN THE LAGOON ARE VERY GOOD. THIS IS DUE TO THE SHALLOW DEPTH OF THE LAGOON COMBINED WITH THE ALMOST-CONTINUAL WIND-MIXING.

PH LEVELS WERE SLIGHTLY HIGH THROUGH MOST OF THE MONITORING. TYPICALLY, PH LEVELS ABOVE 8.5 ARE CONSIDERED HIGH AND POSE A THREAT TO AQUATIC LIFE. PROLONGED EXPOSURE OF A SLIGHTLY HIGHER PH LEVEL OF 9 IS HARMFUL TO SALMONIDS AND PERCH. THE PH RANGE SUITABLE FOR MOST AQUATIC ORGANISMS IS 6.5 – 8.5. RAPID PHOTOSYNTHESIS CAN INCREASE THE PH OF THE WATER (BY REDUCING DISSOLVED INORGANIC CARBON). ALSO, WHEN SURFACE WATERS CONTAIN LARGE AMOUNTS OF DISSOLVED ORGANIC CARBON, THE ASSOCIATED ORGANIC ANIONS MAY ADD ADDITIONAL ALKALINITY. THIS DYNAMIC MAY BE THE BASIS FOR ELEVATED PH IN THE LAGOON. REGARDLESS, PH LEVELS IN THE LAGOON WERE CONSISTENTLY OUTSIDE OF THE OPTIMAL RANGE FOR MOST AQUATIC LIFE, IN PARTICULAR, IMPORTANT FISH SPECIES.

PHOSPHORUS CONCENTRATIONS WERE EXTREMELY HIGH THROUGHOUT THE MONITORING PERIOD. HIGH CONCENTRATIONS ARE MOST LIKELY INFLUENCED BY NUTRIENT-RICH SEDIMENT THAT IS CONTINUALLY STIRRED AND MIXED, IN ADDITION TO INTERACTION WITH ELEVATED PH LEVELS....A TYPICAL SYMPTOM OF A LOW-FLUSHED, EUTROPHIC WATERBODY.

FECAL COLIFORMS WERE FOUND, AT TIMES, TO BE EXTREMELY HIGH. THE THRESHOLD IS 50 COLONIES PER 100ML OF SAMPLE WATER. FECAL COLIFORM COUNTS WERE FOUND TO BE AS HIGH AS 2000+ / 100ML WATER. IF HIGH FECAL COUNTS CONTINUE AFTER RESTORATION IS COMPLETED, ON-SITE SEPTIC SYSTEMS SHOULD BE TESTED FOR MALFUNCTION.

OVERALL, MONITORING DATA SHOWS WATER QUALITY CONDITIONS IN PORT STANLEY LAGOON TO BE SOMEWHAT TYPICAL FOR A SHALLOW, ENCLOSED COASTAL LAGOON. HOWEVER, THERE HAVE BEEN A NUMBER OF SIGNIFICANT HUMAN-INDUCED CHANGES TO THIS AREA, I.E., TIDEGATE, HOUSE/ROAD CONSTRUCTION, ETC.) CULTURAL EUTROPHICATION IS EVIDENT, DUE TO THE CONSEQUENCE OF LOW-FLUSHING CAUSED BY THE EXISTING TIDEGATE. IF THE LAGOON HAD RECEIVED REGULAR (MORE FREQUENT, MORE SUBSTANTIAL) TIDAL FLUSHING OVER THE LAST 50 – 100 YEARS, IT IS LIKELY THIS

TIDAL WETLAND SYSTEM WOULD STILL CONTAIN A DEEPER OPEN WATER LAGOON WITH COOLER TEMPERATURES AND MUCH GREATER BIODIVERSITY.

IT IS EXPECTED THAT, UNLESS RESTORATION MEASURES ARE CARRIED OUT, EUTROPHICATION PROCESSES IN THE PORT STANLEY LAGOON WILL CONTINUE, RESULTING IN FURTHER DEGRADATION OF THE LAGOON AND SURROUNDING MARSH AS WILDLIFE HABITAT. AS IT IS, THE LAGOON AND LOW SALT MARSH WILL CONTINUE TO TRAP SEDIMENTS, RAISING THE LEVEL OF THE SALT MARSH WHILE MAKING THE LAGOON EVER SHALLOWER; AND EVENTUALLY, THE OPEN WATER LAGOON WILL DECLINE AND SALT MARSH WILL BECOME THE DOMINANT FEATURE.

IN LIGHT OF THESE FINDINGS, IT IS RECOMMENDED THAT RESTORATION EFFORTS INCLUDE WATER QUALITY MONITORING DURING AND PROCEEDING RESTORATION CONSTRUCTION.

2002-03 WATER QUALITY DATA (COLLECTED AT APPROX. 2-WEEK INTERVALS FROM 7-10-02 TO 5-22-03)

THRESHO		<16°C*	(6.5 - 8.5)*	>9.5 ML	≤ 1.00 PPM	≤ 0.25 PPM	<0.005 PPM
LD\							
SITE	H2O TEMP	PH	DISSOLVED	NITRATE	AMMONIA		
SAMPLE	OXY.						
7	1	22.2	9.6 - 9.7	8.6 - 9.0	0.00	0.00	
	2	21.7	9.5 - 9.6	9.7 - 11.6	0.00	0.00	
	3	21.8	9.6	9.6 - 10.3	0.00	0.00	
6	1	21.0	8.2 - 9.3	8.4 - 11.2	0.00	0.00	
	2	22.1	9.6 - 9.7	8.6 - 8.9	0.00	0.00	
	3	21.9	8.6 - 9.6	8.3 - 13.4	0.00	0.00	
4	1	22.6	8.8	8.6 - 8.7	0.00	0.00	
	2	21.1	7.5 - 7.6	9.0 - 9.5	0.00	0.00	
	3	22.4	9.0	12.8 - 13.0	0.00	0.00	
5	1	20.6	7.3 - 7.7	9.1 - 9.6	0.00	0.00	
	2	23.0	10.0	12.7 - 13.0	0.00	0.00	
	3	20.7	9.2 - 9.7	9.1 - 11.4	0.00	0.00	
	SURF	20.3	8.1	8.6 - 8.7	0.00	0.00	
	DEEP	19.1	7.7 - 7.8	7.0 - 8.0	0.00	0.00	
	SURF	20.5	8.3 - 8.4	9.2 - 9.7	0.00	0.00	
	DEEP	19.7	8.6 - 8.8	8.3 - 9.0	0.00	0.00	
	SURF	21.0	9.1 - 9.2	9.1 - 9.8	0.00	0.00	
	DEEP	18.6	8.5 - 8.8	7.7 - 8.8	0.00	0.00	
	SURF	16.7	7.8	8.2 - 8.9	0.00	0.00	
	DEEP	16.6	7.9	8.7 - 9.1	0.00	0.00	
	SURF	16.9	7.8	8.6 - 8.8	0.00	0.00	
	DEEP	17.1	7.8	9.0 - 9.4	0.00	0.00	
	SURF	17.9	8.4 - 8.6	10.4 - 11.6	0.00	0.00	
	DEEP	16.8	8.4 - 8.5	9.8 - 11.6	0.00	0.00	
1	SURF	14.6	7.3 - 7.4	8.4 - 8.5	0.00	0.00	
	DEEP	14.1	7.2 - 7.4	8.0 - 8.3	0.00	0.00	
2	SURF	14.4	7.2 - 7.5	7.7 - 8.9	0.00	0.00	
	DEEP	14.3	7.3 - 7.4	8.2 - 8.7	0.00	0.00	
3	SURF	14.2	7.6 - 7.7	9.4 - 10.1	0.00	0.00	
	DEEP	14.2	7.4 - 7.5	9.0 - 9.3	0.00	0.00	
		TEMP	PH	D.O.	NITRATE	AMMONIA	
7	SURF	7.6	7.1 - 7.2	9.2 - 9.8	0.00	0.00	
	DEEP	7.7	7.4 - 7.5	8.7 - 9.2	0.00	0.00	
	SURF	7.7	7.1 - 7.5	9.9 - 10.6	0.00	0.00	
	DEEP	7.5	7.2 - 7.5	9.7 - 11.2	0.00	0.00	
3	SURF	7.7	7.1 - 7.4	9.5 - 10.7	0.00	0.00	
	DEEP	7.9	7.6 - 7.7	10.2 - 10.4	0.00	0.00	

2-4-03	1	TYPE				0.00	0.00			
		VEPB	77	76	77	76	82	0.00	0.00	
	2	TYPE					0.00	0.00		
		VEPB	77	74	75	77	82	0.00	0.00	
	3	TYPE					0.00	0.00		
		VEPB	76	71	72	78	81	0.00	0.00	
5-22-03	1	TYPE				0.00	0.00			
		VEPB						0.00	0.00	
	2	TYPE						0.00	0.152	
		VEPB						0.00	0.152	
	3	TYPE						0.00	0.00	
		VEPB						0.00	0.00	

NOTE: RED INDICATES THAT THE MEASUREMENT IS OUTSIDE THE PREFERRED THRESHOLD FOR THIS PARAMETER